

AUTOMOTIVE INDUSTRY IN THE CONTEXT OF INDUSTRY 4.0 STRATEGY

Juraj SINAY¹, Zuzana KOTIANOVÁ²

Review article

Abstract: The emergence of cyber-physical systems encourages constant adaptation to the complex requirements of new systems, creating new requirements for businesses that must adapt their activity to change. The automotive industry is the decisive industry and the driving force behind the development of the Slovak economy. Changes that have occurred in the automotive industry are reflected in the high automation of processes, which is reflected in the need to change management, in particular the need for on-line automotive tracking.

Keywords: Safety; industry 4.0; sensors; automotive industry; risks.

Introduction

Slovak industry is focused on the area of automotive industry. The automotive industry creates more than 44% of the total GDP in industry, which is up to 26% in the Slovak Republic. The objectives of car production - increasing their number on markets, the latest technologies with a high degree of digitization and automation are being used in this industry sector. Since the adoption of the Intelligent Industry Concept for Slovakia (October 2016), a clear position of the Government and Ministries on this topic is already in place in Slovakia, and Industry 4.0 is becoming a national priority. It is a necessary and anticipated process for maintaining competitiveness. Implementation of intelligent industrial processes will change not only Slovak production companies, but will also become the cornerstone of development of Slovakia's economy with a significant impact on society.

Materials and methods

Industry 4.0

The term *Industry 4.0* (Fig. 1) means a way of managing activity within technologies where production and logistic processes, and within them machines and products, communicate with each other and organize individual steps in the production process autonomously and in synergy with the human factor. The goal is for the processes to consider

the requirements for safe operation so that, at the end of production process, the products meet customer requirements. Companies are heading towards the so-called Smart Factory.

The term Industry 4.0 represents:

- linking production to information and communication technologies;
- linking customer requirements directly with machine and device data;
- communication of machines with machines;
- autonomous data acquisition and processing at both vertical and horizontal level;
- decentralized management;
- separate production created by communication between semi-finished products and machinery - flexible, efficient and economically saving resources (Pattform 4.0. 2018).

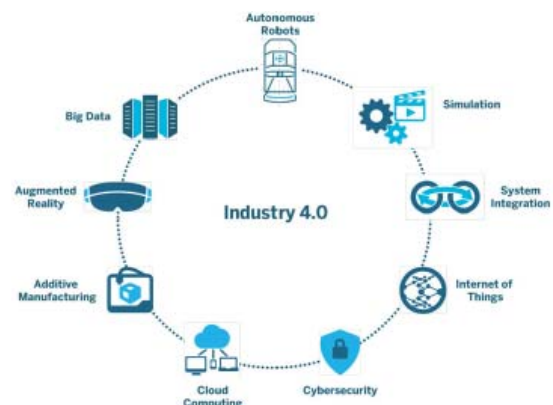


Fig. 1. Industry 4.0 (touchit.sk, 2017)

¹ Technical University in Košice, Faculty of Mechanical Engineering, Košice, Slovakia, juraj.sinay@tuke.sk

² Technical University in Košice, Faculty of Mechanical Engineering, Košice, Slovakia, zuzana.kotianova@tuke.sk

- Industry 4.0 is based on two main cornerstones:
1. digitization - products, processes, equipment, services;
 2. application of exponential technologies.

Industry 4.0 brings technical and social development to the current world of work. One of the strategic tasks in the near future is the interconnection of adequate education, currently known as Education 4.0, based on the results of applied research and innovation, to Safety 4.0, Prevention 4.0, Quality 4.0, and the like (Fig. 2).

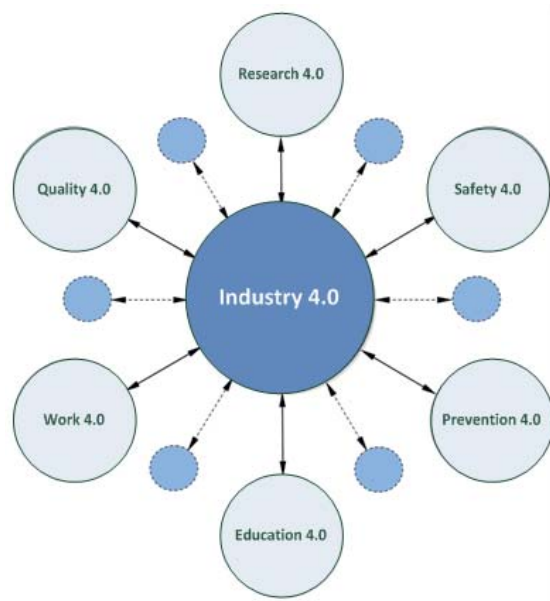


Fig. 2. New challenges in Industry 4.0

The increasing degree of digitization causes changes in the nature of work. New communication models, new forms of work /homeworking/ as well as new professions will emerge. This means that there are not only changes in technology but also in the area of work. This results in:

- new forms of hazard identification and risk assessment,
- development of new methods, procedures and instruments for identifying new risk parameters.

It follows that meeting the requirements of Industry 4.0 will have the necessary impact on:

- quality of work,
- requirements for qualification,
- new ways of organizing work and changing of many interactions and interactions in the human-machine-environment interface that we can imagine as new forms of collaborative work in the context of a digital factory.

Individual companies according to the degree of implementation of Industry 4.0 elements can be partitioned, for example, to five levels. Each level has a specific division of Integrated Safety & Security.

The individual levels of Industry 4.0 implementation:

1. Level - Basic level of digitization: The company does not address sector 4.0, requirements are not met or only partially met.
2. Level - Digitization between departments: the company is actively engaged in the topics of Industry 4.0. Digitization is implemented in various departments and the first requirements of Industry 4.0 are implemented throughout the company.
3. Level - Horizontal and vertical digitization: The company is digitized horizontally and vertically. The industry 4.0 requirements were implemented within the company, and the information flows have been automated.
4. Level - Full digitization: The company is fully digitized beyond enterprise boundaries and integrated into value networks. Approaches in industry 4.0 are actively pursued and embedded within the corporate strategy.
5. Level - Optimize Full Digitization: The Company is a model for industry 4.0. Strongly cooperates with its business partners and therefore optimizes its value networks.

Cyber-physical Systems

Cyber-physical Systems, Fig. 3 (hereinafter referred to as CPS) represent the link between real (physical) objects and processes processing information (virtual-cybernetic), often operating over an open, partially global and interconnected information network. It is a dynamic and meaningful course of production that may result in data, information, and services found on external production networks being taken back, if necessary. Thanks to these functional capabilities, the devices become adaptive, self-managing and self-configuring, or possibly self-optimizing production components (Huber, 2016).

CPS represents:

- flexible (SMART) machines, devices, goods and components;
- system functionality of these devices distributed over the network;
- hierarchy of interconnected components;
- communication between components;
- product as part of the network (Industry4, 2018).



Fig. 3. Cyber-Physical Systems (Industry4.sk, 2018)

CPS, as all other technologies, enable further optimization and improvement of production. CPS are seen as a means to control the ever-increasing complexity of the production industry. Developed CPS sensorics enable real-time collection of data in huge quantity and various structure, which enables the systems to predict future behaviour, to analyse errors, and to evaluate and make decisions. These complex systems are referred to as "Big Data" and are part of the so-called Smart Data (autonomously controlled and responding data systems, such as data lifecycle, 3D reporting, predictive maintenance and quality, etc.). CPS actuators which operate autonomously are used to implement these decisions, i.e. the performance of control instructions, and they enable continuous performance of the control system while responding to external and internal stimuli (Gregor, 2016).

According to Obermeier, the starting point for understanding CPS is the understanding that every object that works on the basis of the so-called built-in systems with automatic control capability, and equipped with sensors able to capture data, software for their processing and evaluating the effects of real phenomena of data structures such as the Internet, enables communication in the interface man-machine-environment, and the repeated process with the other CPS can be connected into one network, the so-called Internet of Things (IoT) and Internet of Services (IoS).

Automotive Industry versus Industry 4.0

Slovak industry is oriented towards the automotive industry; therefore, the individual elements of Industry 4.0 are applicable in this direction. With respect to technological advances, there are many factors in this sector, particularly the high level of automation and digitization. Automotive industry elements of Industry 4.0 are:

- *augmented reality*, using virtual simulations to design workplaces, processes, and setup and repair machines;
- *virtual assembly*, which allows employees to estimate how to best handle the task by means of control module (Oravec et al., 2017);
- *360-degree networking* (Mixmotor, 2015);
- *autonomous robots and machines*, based on cooperative partnership machine-machine, machine-man that frees man from risky activities;
- *Smart Factory*, by incorporating the real world into the digital world it is possible to create the so-called digital twin that allows real-time display of processes, systems and entire production halls;
- *higher flexibility*, faster response of production to global market fluctuations and individual customer demand. Digital production also facilitates the production of increasingly more complex products;
- *increased efficiency*, cost-effective use of resources as well as energy, buildings or inventory is a decisive factor;
- *higher speed*, flexible production processes, simplified adaptation of existing production facilities and installation of new equipment enable easier and more efficient manufacturing processes. This allows for shorter innovation cycles; product innovations can be quickly introduced on the market;
- *intelligent logistics*, from configuration and ordering vehicle by customer, through identification of the need for constructional components and their procurement to production and shipping;
- *3D printing*, especially in additive production or development and subsequent testing.

Horizontal and vertical system integration enabling data flow control across company and corresponding software equipment - this allows for use of complete 3D information along the entire value chain (Fig. 4).

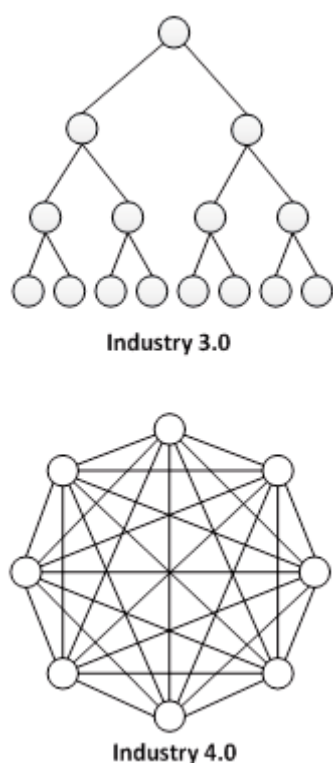


Fig. 4. Difference in Information Flow within Industry 3.0 and 4.0

From the point of view of use, sensors can be divided into:

- a) safety sensors,
- b) operational sensors,
- c) communication sensors.

Fig. 5 illustrates the data flow in Industry 4.0, where it can be said that from safety point of view, the hierarchy of risks begins with the sensor. It is necessary to look for new methods and procedures in the process of identifying and managing risk sufficiently taking into account communication flows, data mobility and their characteristics, the amount of data being processed and assessed, and the way they are managed. Industry 4.0 represents flexible production of highly personalised products by means of collaborative robots and other mechanisms. Their autonomy, however, comes with the potential to create new hazards and is therefore one of the top topics addressed in the context of occupational safety - there is a real risk of collision between robot and man.

Results

Types of risk in the context of Industry 4.0 can be summarized as follows:

- new forms of risk resulting from using new technologies;
- unreliable operation of sensors;
- bad transmission of information;
- new work activities in new conditions;
- increasing trend of psychological risks;
- information risk related to loss of data and loss of company know-how;
- risk of collision or pressing an employee by a collaborative robot;
- risks related to home working;



Fig. 5. Data Flow within Industry 4.0 (Obermaier, 2016)

- sensitivity and vulnerability of data related to cyber attacks;
- small number of qualified employees;
- electromagnetic emissions.

Conclusion

Within the current progress of Industry 4.0, safety is monitored at the level of achieved intelligence of robots of industrial equipment as well as at the level of system and communication security of data and their management.

Implementation of the framework focus of Industry 4.0 requirements will have an inevitable impact on quality of work, qualification

requirements, new ways of organizing work and changes of interactions and synergy in man-machine-environment interface that we can imagine as new forms of collaborative work in the context of a digital factory.

Acknowledgements

This contribution was developed by implementing APVV-15-0351 *"Development and Application of Risk Management Models in Conditions of Technology Systems in Compliance with Industry 4.0 Strategy"*.

References

- Basic Elements of Industry 4.0. [online]. industry4.sk, 2018 [cit. 2018-02-06]. Available at: <http://industry4.sk/>.
- Gregor, M. 2016. Industry 4.0 - Industry 4.0. In ProIn. 2(16): 44 - 46. ISSN 1339-2271.
- Huber, W. 2016. Industrie 4.0 in der Automobilproduktion. Haar: Springer Vieweg. 303. ISBN 978-3-658-12732-9.
- Industry4 brings answers to how to launch Industry 4.0 in companies. [online]. touchit.sk, 2017 [cit. 2018-12-16]. Available at: <https://touchit.sk/industry4-prinasa-odpovede-ako-rozbehnut-industry-4-0-vo-firmach/107366>.
- ISO 31000:2009. Risk management - Principles and guidelines.
- Obermaier, R. 2016. Industry 4.0 as an entrepreneurial design task. Passau: Springer Fachmedien Wiesbaden - Universität Passau. 319. ISBN 978-3-658-08165-2.
- Oravec, M., Tomašková, M., Balážiková, M. 2017. Development and Application of Risk management methods for the Industry 4.0 platform. 1st edit. Košice: TU.
- Plattform Industrie 4.0. [online]. plattform-i40.de, 2018 [cit. 2018-02-06]. Available at: https://www.plattform-i40.de/I40/Redaktion/DE/Downloads/Publikation/rami40-eine-einfuehrung.pdf?__blob=publicationFile&v=5.
- Revolutionary Industry 4.0 after Daimler. [online]. mixmotor.eu, 2018 [cit. 2018-12-16]. Available at: <http://mixmotor.eu/15042/revolucny-priemysel-4-0-po-daimler-ovsky>.
- What's Industry 4.0. [online]. industry4.sk, 2018 [cit. 2018-02-05]. Available at: <http://industry4.sk/o-industry-4-0/technologie/>.